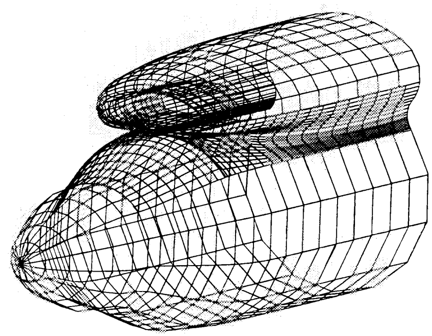
Solving the 'Hidden Line' Problem

Highlighting spinoff examples in the field of computer processing is an important software advance in computer-aided design

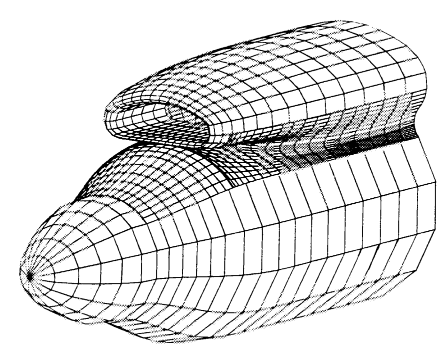
Aerospace engineers have been using computer-generated graphics as a design tool for years and the technique has spread to many other fields of industrial design, such as architecture, automobile development and metallurgy. David R. Hedgley, Jr., a mathematician at NASA's Dryden Flight Research Center has made an important contribution to further advancement of this art by solving a problem that has confounded graphics experts since computer-aided design began.

The problem was that a computer does not "see" a solid object as the human eye sees it; the computer defines the *whole* object without regard to perspective. For example, imagine looking at an office desk; you see the top surface and one or two sides, depending on your viewing angle. But—prior to Hedgley's solution—if a computer was asked to produce a picture of a desk it would show all the desk's surfaces, angles and curves, regardless of whether they were on the side facing the viewer or on the back and under surfaces hidden from the viewer. This resulted in a cluttered, confusing picture that slowed and complicated the design process.

Mathematicians around the world worked for years on this "hidden line" problem, considered to be one of the most difficult in the field. Some achieved partial solutions, but they were incomplete or insufficiently accurate. Working at Dryden on aircraft wing flutter analysis, David Hedgley saw a need for a more accurate method of simulating wing aerodynamics by computer. In 1981, after two years of effort, he came up with a computer program that considers whether a line in a graphic model of a three-dimensional object should or should not be visible. Known as the Hidden Line Computer Code, the program automatically removes superfluous lines and permits the computer to display an object from a specific viewpoint, just as the human eye would see it.

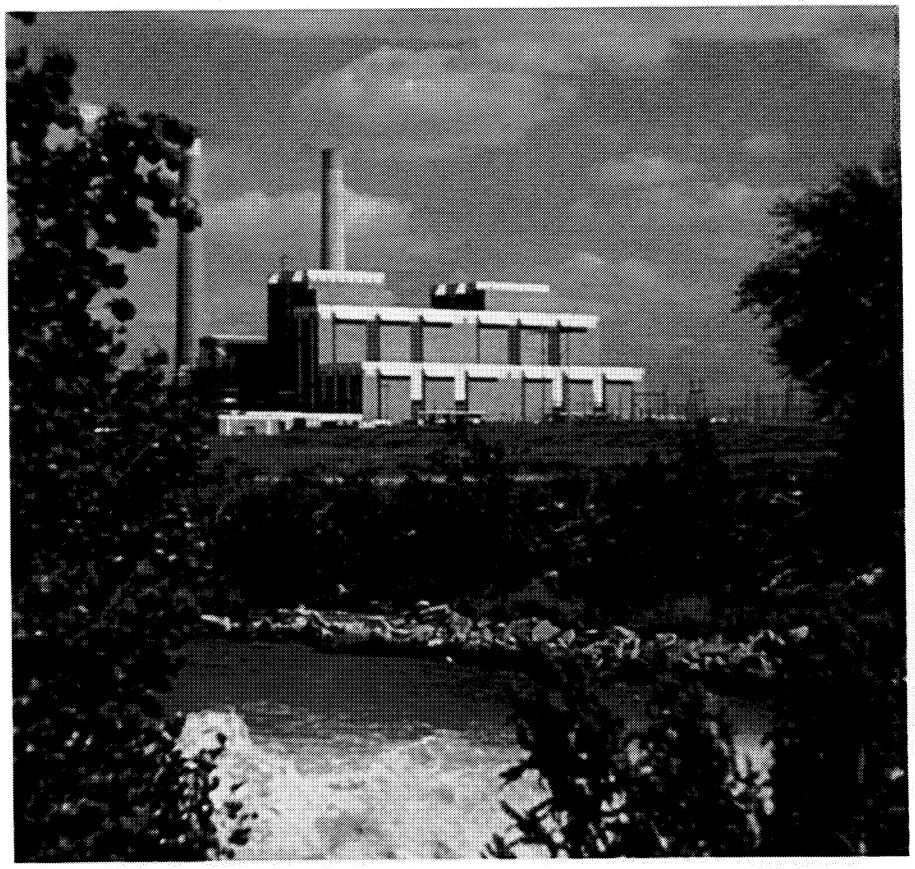


The above illustration is a computer-generated drawing of an engine nacelle for an advanced turboprop aircraft design investigated by Lockheed-Georgia Company. The initial drawing has hundreds of extra lines, because the computer shows all the lines resulting from its stored input without regard for perspective. A new NASA-developed computer program automatically removes the hidden lines to produce clean, unambiguous drawings like the one below.



In April 1982, the Hidden Line Computer Code was made available to public users through NASA's Computer Software Management and Information Center (COSMIC®). It was an immediate best seller. In its first year, the hidden line software package set a record for sales of an individual COSMIC supplied program. Hidden Line Computer Code users now number in the hundreds; they range from small companies to Fortune 500 corporations and they embrace a wide variety of industries.

An example of a user is Rowland Institute for Science, a new non-profit center for basic research located in Cambridge, Massachusetts. Rowland chemists have used the Hidden Line Computer Code to model molecule shapes visually; removal of hidden or overlapping lines provides an accurate image of molecular structure, free of ambiguities of perspective that could be misinterpreted.



Among the many applications of the Hidden Line Computer Code are drawings of planned construction site locations. The computer presents graphics of many different viewpoints, so that engineers can determine the most effective design of earthwork and structure to assure that the facility will blend with the environment. Such techniques were used by the Nebraska Public Power District in construction of the Gerald Gentleman Station pictured, a power generating plant near Sutherland, Nebraska.

Several departments of Lockheed-Georgia Company, Marietta, Georgia use the program in generating computer drawings of aircraft models. These models are combinations of individual panels representing a particular airplane component—a wing, tail or nacelle, for example. A model may have as many as 2,500 panels, resulting in hundreds of excess lines; removing the hidden lines presents a clear, unambiguous drawing, which is used to verify that the aircraft design has been properly modeled. After verification, aerodynamicists use the drawings to determine airflow around the component; airflow analyses help refine the aircraft design. The speed and accuracy of the Hidden Line Computer Code reduce computer time and improve productivity at Lockheed-Georgia; at current levels of usage, the company recovers the purchase cost of the program every two days.

The Nebraska Public Power District (NPPD), Columbus, Nebraska uses the program in several different ways, for example, in producing drawings of substation site locations or of transmission towers. NPPD also operates a nuclear power station, and engineers use the program to depict a three dimensional simulation of the power distribution in the nuclear reactor; displaying power levels graphically helps determine whether power generation in any one segment should be suppressed or increased for greater efficiency. Another application of the code is generation of 3-D bar charts showing power usage in individual towns served by NPPD.

The hidden line program is an example of how NASA is helping American businesses reduce automation costs by making available already-developed computer programs that have secondary utility. Development of an entirely new program may entail costs equivalent to 30–40 percent of the total cost of computerizing a business or a process. Frequently, however, a program developed for one purpose can readily be adapted to a totally different application. Thus, business and industrial users can save time and money by taking advantage of the service COSMIC provides in the interest of national productivity.

Located at the University of Georgia, COSMIC gets a continuous flow of software developed by NASA, the Department of Defense and other technology-generating agencies of the government. COSMIC identifies those that can be adapted to secondary usage, stores them and notifies potential customers of their availability through a catalog and through the NASA publication *Tech Briefs*.

COSMIC's library numbers some 1,300 programs applicable to a broad spectrum of business and industrial applications. Customers can purchase a program for a fraction of its original cost—the Hidden Line Computer Code, for example, costs less than $400—and in most instances they get a return many times their investment, even when the adaptation cost is included.

Acceptance by business and industry has been extraordinary; the Center has distributed thousands of programs, some of which have allowed savings amounting to millions of dollars. Thus, COSMIC's service represents one of the broadest areas of economic benefit resulting from secondary use of technology developed by the government.